



Case History

Hydro Power: treating the source of a problem, not just a symptom

*By S. A. Hurricks and B. A. Urquhart.
Condition Monitoring Engineers
Northern Thermal Group
Electricorp Production
New Zealand*

This article demonstrates how the correct application of instrumentation and diagnostic procedures can highlight otherwise obscure

underlying causes of machinery problems.

Electricorp Production is a business unit of the Electricity Corporation New Zealand Ltd., which generates 96 percent of New Zealand's electricity. Electricorp Production produces 75 percent of its electricity from 30 hydroelectric power stations. The North Island has 16 of these stations with a combined capacity of 1,585 MW.

Eight stations are located on the Waikato River, the longest river in New Zealand. Water is cascaded from one station to the next to extract as much of the Waikato's potential energy as possible. Waipapa Power Station, commissioned in 1961, is the 6th in line on the Waikato system. Waipapa has three 17 MW Kaplan turbine type machines which rotate at 125 rpm. Figure 1 shows a simplified machine cross-section.

Machine history

In 1982, excessive vibration on the combinator prompted an investigation into the Number 1 generator's dynamic condition. The combinator is the hydraulic control servo which controls the Kaplan turbine's variable blade pitch.

A vibration survey was made of the shaft motions using a **Bently Nevada Digital Vector Filter 2 (DVF2)** modified to remove the display blanking for the slow-running hydro machines. Three proximity probes were attached at the following locations: One at the lower guide, one just below the main guide bearing and one on the upper guide bearing. An optical Keyphasor® was used to obtain speed and phase information. The vibration survey revealed excessive generator unbalance of 16 mils (416 μm) peak-to-peak (pp) at 1X rpm at full speed and no load.

The combinator vibration frequency was below the response of a velocity transducer, and a low frequency accelerometer was not available. In order to measure the combinator's absolute motion, a large crane hook was used as an inertial reference to magnetically mount a proximity probe. The measured motion varied between 4.7 mils and 19.7 mils (120 to 500 μm) pp. It appeared that the combinator head was being "rattled" by contact in the upper guide oil seal area.

Machines of this size and vintage typically have no installed monitoring equipment other than bearing temperature alarms. Human observation is used to monitor the machines. Before 1960, installed vibration monitoring wasn't considered necessary on low-speed machines with massive bearings.

Recommendations - 1982

The vibration survey showed that generator balancing was necessary as soon as it was convenient. The client, at this stage, did not request further work on this machine.

Further developments - 1989

No further action was taken until 1989 when another request was made to investigate the problem. The machine was reassessed with the same **Bently Nevada DVF2**. The same conclusions were drawn.

The machine was balanced a month later by adding a 79 pound (36 kg) main weight and a 35 pound (16 kg) trim weight to the generator, at a radius of 8.5 feet (2.6 metres). This reduced the generator shaft motion to approximately 2 mils (50 μm) pp, which is ►

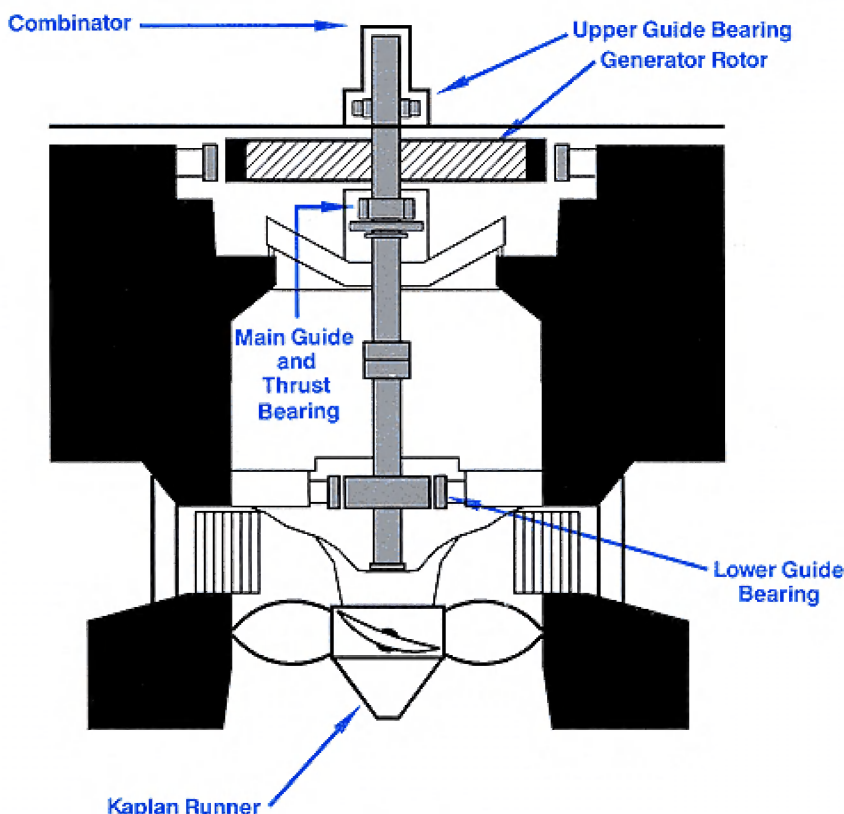


Figure 1
Machine cross section of Waipapa Hydro Power Station

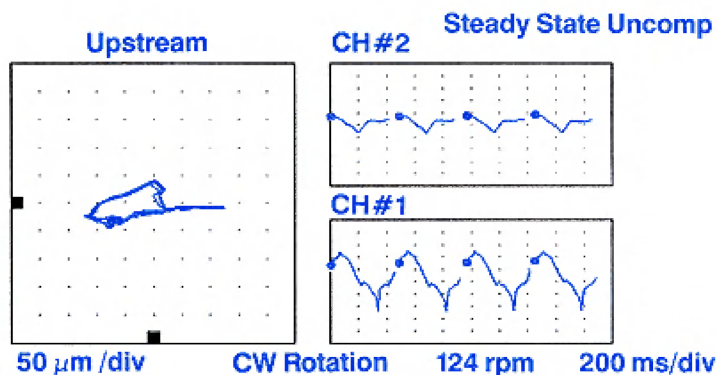


Figure 2
Orbit/Timebase plot of main guide bearing

acceptable when the estimated runout is 2 mils to 3 mils (50 to 75 μm) pp. The combinator head no longer exhibited signs of internal contact.

Reoccurrence

A little over one year later, an urgent request for help was received from Waipapa. The temperature of the generator's upper guide bearing had greatly increased for no apparent reason. The machine had been taken out of service and the bearing pads inspected. White metal on one bearing pad had wiped where shaft contact had occurred. The repaired bearing pad was too tight to refit, and shims had to be removed to allow the pad to be reinstalled. On recommissioning, the temperature again increased above allowable limits.

Diagnostic approach

A shaft and bearing motion study on the Number 1 generator was performed using a newly-acquired Bently Nevada **ADRE® 3 System**, consisting of a **108 Data Acquisition Instrument (DAI)**, **ADRE® 3 Software**, computer, Keyphasor®, proximity probes and an accelerometer. The **108 DAI** was programmed to capture data at one-minute intervals from XY proximity probes measuring the upper guide bearing journal motion and an accelerometer on the upper guide bearing support structure measuring upper guide bear-

ing housing motion.

After the machine was shut down, the data was downloaded to a portable computer so that the shaft Orbit pattern could be analyzed with the **ADRE® 3 Software**. It was evident from observing the shaft Orbit (Figure 2) that shaft contact had occurred.

Findings

The upper guide bearing on these machines is only a relatively small, steady bearing. The initial question was "Why couldn't the bearing pad be reinstalled after repair?" Obviously, the shaft had moved over while the bearing pad was removed for repair. Since this happened while the machine was stationary, it indicated that this problem was not purely dynamic.

The next question to be answered was, "Why didn't the main guide bearing restrict the shaft movement, preventing contact?" One possible hypothesis, as frightening as it might have been since the generator rotor alone weighs 100 tons, was that the whole main guide bearing assembly was not securely anchored to its foundation!

When Waipapa's maintenance personnel inspected the main guide bearing assembly, they discovered that it had worked itself loose. The large dowel pins, which locate the bearing carrier assembly, had worked themselves out, allowing the bearing assembly to move.

Consequently, the shaft radial load was transferred to the small upper guide bearing. As a result, the upper guide bearing was overloaded, causing the contact and high temperatures. The main guide bearing assembly was realigned and tightened. The machine has run with no further problems since then.

Conclusions

This exercise highlighted the value of visual evidence, in this case a shaft Orbit plot, to help condition monitoring personnel change their approach to investigating a problem. Before they gathered machinery information using **ADRE® 3**, the maintenance crew planned to realign the upper guide bearing. That would have been a needless exercise, as the underlying problem would still have had to be addressed. ■

★ ★ ★

Acknowledgements

The authors wish to thank the management of the North Island Hydro Group for their permission to publish this article. They would also like to acknowledge the assistance received from Waipapa's staff during balancing and analysis exercises.

S. Huricks and B. Urquhart work as vibration specialists based at Huntly Power Station and are consultants at other stations.

